

Ottawa Hull K1A 0C9

(21)	(A1)	2,155,850
(86)		1993/02/10
(43)		1994/08/18

(51) Int.Cl. <sup>6</sup> G03H 1/20; G03H 1/02

(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Process Printing Material and Device for Reproducing  
Holographic Fine Structures and Other Diffraction Grids  
on Print Products

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(57) 10 Claims

Notice: This application is as filed and may therefore contain an  
incomplete specification.



**Summary**

The description relates to a process for the simultaneous replication and direct application of holograms and other diffraction grids on various printing material (6), especially paper or cardboard. It is carried out in the shaping process using a matrix bearing the hologram as a surface relief structure. One or more coats of lacquer (3, 7, 9) are applied to a printing material (6) with a substantially smooth surface and thus the surface of the printing material (6) is smoothed further. The hologram is simultaneously shaped into the surface of the coating applied to the printing material (6). The lacquer coating (3) can be hardened by radiation and the lacquer coats (3) are hardened from the matrix side through the UV-transparent matrix and through a matrix support (14) (a plate or cylinder) which is also UV-transparent. The lacquer coat(s) (3, 7, 9) is/are essentially hardened before the printing material (6) is removed from the matrix and in contact with the matrix or the shaping cylinder (Fig. 4).

**Translation****Process and Device for Reproducing Holographic Fine Structures and Other Diffraction Grids on Print Products**

The invention pertains to a holographic reproduction process for the shaping of holograms and other diffracting or refracting fine structures (diffraction grids) in accordance with the preamble of Claim 1 on different printing materials and a device for applying a hologram to a printing material.

Holography is a recording and reproduction technology which makes it possible to represent objects spatially. Films and plates are normally the storage medium and data carriers.

A normal hologram is either an original or can be copied optically, for example as a photo, on an economical basis only in relatively limited numbers.

How to shape the structure of a surface relief hologram thermoplastically and then to transfer it to different printing materials (carriers) is known.

Up to now the reproduction of surface relief holograms and their integration into print products has consisted of three production stages.

Normally, the holographic picture is shaped into a carrier material as a surface relief structure and only then is it transferred to the printing material in a third

process stage following the addition of an adhesive or bonding agent.

The shaping is done into plastic thermoplastically workable surfaces by means of stamping dies, belts, or rollers and using pressure and temperature.

Previously such a stamped hologram was processed into two product variations following the shaping, specifically into so-called sealing holograms or into self-adhesive holograms.

Both product variations are initial products which can be applied to the printing material in an additional operating cycle only during further processing or packaging. Direct thermoplastic stamping into printing materials without subsequent transferring steps is also possible, as is known from the inventor's DE-A 37 44 650.

Holograms are normally manufactured as follows:

In the preliminary stage, the so-called mastering, a laser transmission hologram of the original object is made by means of laser light as a three-dimensional picture of the object. This master hologram, which stored the entire surface information of the object in an interference sample, can only be seen under laser light however.

A copy of the laser transmission hologram, the master, is made which can be seen with normal, directed white

light. This type of hologram is called a white light transmission hologram.

As well other diffraction grids which create decorative or technically/scientifically applicable light effects are produced holographically by means of laser light or mechanically by means of engraving.

In order to obtain a surface relief structure which can be shaped for the stamping, reproduction or replication process, this master hologram or diffraction grid is copied into a plate coated with photoresist or into other materials forming a surface relief.

Depending on the partial intensity distribution during exposure, the applied photosensitive resist hardened more or less strongly in the negative process or dissolved more or less strongly in the positive process. As a result of the subsequent development, a surface relief structure corresponding to the relevant cross-linking or resolution is exposed. The light is diffracted at this and at the subsequently stamped surface structure, producing a picture.

The diffracting and refracting surface relief structures can also be produced mechanically, i.e. cut or engraved or engraved by means of laser. The resolution or line width of mechanically produced diffraction grids depends on the technical processes chosen to produce them.

A surface relief hologram has a fine structure of circa 0.2 to 1  $\mu$  difference in height and a resolution of 800 to 1,800 lines per millimetre.

In order to be able to shape the subsequent stamping die electrogalvanically, the surface of the photoresist is made electrically conductive. This results from chemical metallization by means of nickel or silver reduction processes. Vacuum coatings or sputterings can also be carried out.

The so-called family is drawn from the photoresist in galvanic nickel sulphamate baths via positive/negative processes. For example, the so-called production shim is drawn from the photoresist in nickel as stamping matrix in several stages. The family generated here consists of the great-grandmother, grandmother, diverse mothers, and as many daughters as desired, the production shims (stamping matrixes).

The production matrixes produced from the hologram are between 50 and 100  $\mu$  thick and thicker, as required, and can be reproduced in the thermoplastic stamping process. For special purposes it is appropriate to manufacture thicker stamping plates and stamping dies, endless loops, or cylinders.

Using specific pressures and temperatures, the surface structure of the stamping matrix is stamped into thermoplastically workable surfaces or lacquer layers. Of decisive importance in this is the harmonization of the three

stamping parameters pressure, temperature, and speed in a manner suitable for the material and motive. The surface heating of the materials to be stamped must be controlled very precisely. The ideal stamping temperature is to be found in a specific range between the softening point and the melting point of the material.

The surface to be stamped can already be metallized prior to stamping. In particular, this allows for optical control (quality control) of the stamping result during stamping. In addition, metallization prevents the printing material adhering to the matrix.

Up to now mainly two materials and systems have been used:

#### A Self-adhesive products

Stamping was carried out into plastic sheeting or into co-extruded sheeting or into thermoplastic lacquer systems which were applied to thermally dimension-stable substrates (carriers), like polyester sheeting. As a rule these systems were self-adhesive or laminated onto various carriers.

The typical layer structure of normal holographic or diffractive self-adhesive sheeting consists essentially of:

1. Polyester substrate (carrier) 50 to 100 my thick,
2. Bonding agent optional (primer),

3. Lacquer layer, thermoplastically workable, as hologram carrier, 0.9 to 2.5 my thick or ca. 1.2 - 3.5 g/qm,

or alternatively, instead of 1 + 2 + 3, only:

4. PVC or vinyl sheeting or other thermoplastically workable sheeting, 50 to 100 my and thicker;

and then:

5. metallization ca. 300 Angstroms thick for a good optical density of 1.8 - 2,
6. Acrylic adhesive 4 - 10 g/qm,
7. Silicone release paper, e.g. 50 g/qm for labels (rolled goods) or e.g. 90 g/qm for stickers (stay-flat version).

When applying a self-adhesive hologram, the hologram is glued onto a base together with the carrier film. For this purpose a self-adhesive coating is applied after stamping to the metallized side of the carrier film, which is normally 50 my and thicker, and it is covered with a silicone release paper which is removed before or during application.

## B Heat-seal sheeting

During stamping of holograms into heat-seal sheeting, the lacquer layer for example, which contains the stamped holographic fine structure, is subsequently transferred to the printing base in a further production stage by means of a heat-activated heat-seal adhesive.

The typical layer structure of normal heat-seal sheeting consists essentially of:

1. Polyester substrate (carrier), 12 to 25 my thick,
2. Separating layer 0.5 - 2 g/qm,
3. Perhaps a clear or coloured covering lacquer layer, 0.5 - 1.5 g/qm,
4. One or more lacquer or paint layers as actual hologram carrier, 0.9 to 2.5 my thick, ca. 1.1 - 3.25 g/qm,
5. Metallization ca. 300 angstroms for good optical density of 1.8 - 2,
6. Heat-seal adhesive 0.7 - 2.5 g/qm.

As a rule metallization is carried out prior to stamping but can also be done afterwards.

The structure-absorbing lacquer used is normally optically clear and thermoplastically workable. Its softening point or the glass transition temperature is higher than the melting point of the heat-activateable heat-seal adhesive subsequently applied to the metallization. Therefore this heat-seal adhesive can be applied to the stamped metal side of the heat-seal sheeting only after the stamping has been carried out.

The holograms or diffraction grids located in the lacquer of the heat-seal sheeting are now transferred to the printing material by means of specific application pressures and temperatures.

The heat-seal adhesive and the separating layer are activated by the heat applied by a heated pressure plate or roller.

The lacquer layer of the sheeting is combined with the printing material under a certain pressure. Following a certain contact time, the polyester sheeting is then removed from the new composite formed.

Even if the thermoplastic stamping process itself can be described as relatively fast, e.g. between 2,500 and 25,000 cycles per hour, the additional required application onto the product to be decorated, especially in the heat-seal process, represents a temporal and cost bottleneck.

The sealing speed with a heat-seal flat press is 800 to 2,200 cycles per hour. The sealing speed with a heat-seal cylinder machine is 1,500 to 3,500 cycles per hour.

A cycled lifting or coding press can attain up to 6,000 cycles per hour (hologram applications) with small formats.

The sealing speed is limited by the fact that the stamping material requires a specific temperature and a certain contact time on the printing material before perfect adhesion is achieved.

In addition, there is the danger of bubbles being produced as a result of gas exiting from the printing material or the adhesive, which is particularly disturbing in flat presses.

Consequently, the disadvantages of this process are, in particular:

additional material requirements/costs for the heat-seal sheeting itself; second, the application of heat-seal adhesive after stamping; and third, the additional heat-seal process required to transfer the hologram.

The known processes described above are too expensive, especially taking into account the high production numbers and speeds customary in today's communications technology and the necessity of a reasonable cost-benefit relationship.

In US-A-4 758 296 a continuous process is described for the application of a hologram onto a printing material in which a lacquer layer is applied to a substantially transparent belt- or cylinder-shaped hologram carrier and hardened by a radiation source located at the back of the printing material while the printing material passes the hologram carrier. This process is suitable only for radiation-transparent printing materials.

The invention is based on the technical problem of specifying a process for the continuous direct printing of

holograms or other fine structures on a printing material which is also radiation-permeable, in particular paper, cardboard, and opaque sheeting, which allows for a high printing speed at a low cost.

In addition, the invention is based on the problem of specifying a device for the shaping and direct application of a hologram onto a printing material.

These problems are solved through the invention described in Claims 1 to 5. Advantageous developments of the invention are specified in the sub-claims.

The inventions results in the following advantages, in particular:

1. elimination of the previously required adhesive coating of the holograms after stamping,
2. elimination of the application stage required after application of the adhesive coating, i.e. transfer of the finished, stamped hologram to the printing material.

The inventive process makes it possible to print directly onto paper, cardboard, and other printing materials without using an intermediate carrier and without intermediate stages.

Materials and further processing stages previously required for heat-seal holograms or self-adhesive holograms can be eliminated by the invention.

The invention allows the mass reproduction of holographic data or diffraction grids in a manner suitable for the print media at a low cost and with considerably increased production speeds.

The inventive process of the shaping of holograms and other diffraction grids by means of UV-hardening by radiation through a UV-transparent printing cylinder and through a UV-transparent matrix offers great qualitative, technical and economic advantages compared to known thermoplastic processes and especially compared to other radiation-hardening processes, such as the very process-intensive and hardware-expensive electronic radiation hardening.

In particular in shaping holographic fine structures and other diffraction grids onto printing material which are mainly UV-transparent, like paper or cardboard or opaque sheeting, synthetic papers and fabrics, the inventive process offers great advantages because now the medium to be shaped can be hardened in contact with the shaping cylinder by means of UV-radiation through the cylinder and matrix.

Previously, with UV-impermeable printing materials, it was only possible to work with thermoplastic shaping or to harden the shaping medium by means of electronic radiation

hardening which penetrated the paper from the printing material side or the carrier sheeting side.

In accordance with the invention, shaping and hardening, especially in the rotation process, are carried out by means of UV-radiation from the matrix side through a UV-transparent matrix and also through a UV-transparent shaping cylinder wall by means of a UV-radiation source located in the interior of the cylinder.

The shaping and hardening can also be carried out in individual stage processes (step-and-repeat). In this case, in contrast to the rotation process, a flat matrix and a flat matrix carrier plate are used, which are also both UV-transparent.

The following product shapes, for example, can be manufactured with the same basic machine design using the inventive process.

1. Paper and cardboard and other mainly UV-transparent printing materials or synthetic papers, e.g. so-called PE-papers/polyester papers.

Reasonably priced paper is processed primarily into labels, gift and wrapping paper, cardboard and packaging, decorative paper or wallpaper.

2. Self-adhesive plastic sheeting, transparent or opaque, in thicknesses of 15 to 150 my and more. This product form can be partially equipped with

a self-adhesive or processed to laminates. In doing so, solid substrates or also textiles can be used. The transparent product form is used, also without metallization as transmission diffraction grid or diffraction grid, for technical, scientific, and optical purposes, such as light and show effects.

3. Sheeting-multiple layer systems on transparent or opaque sheeting in which the shaping UV-hardening medium remains on a carrier sheeting (substrate) after hardening and the composite can also be strengthened by an additional bonding agent (primer) applied to the substrate.

Product forms 2 and 3 are predominantly equipped with and product form 1 partially equipped with a self-adhesive and these product forms are processed to decorative sheetings as sheet or rolled goods or stamped out of them and cut into holographic or diffractive products, like pictures, labels, stickers, marking and adhesive tapes.

4. Heat-seal sheeting and other transfer sheeting in which, in place of the bonding agent, a separating layer (release coating) between the shaping medium and the carrier sheeting is applied in advance to the carrier sheeting. This separating layer has a lower tactility to the UV-hardening shaping medium than the heat-seal adhesive or transfer adhesive applied to the shaping medium and the metal layer after metallization has to

the printing material, which ensures that the very thin motive-bearing shaping layer can be detached from the carrier and that this very thin motive-bearing shaping layer is permanently bonded to the new printing material.

5. Textiles, fabrics, dimension-stable fine fabrics (e.g. microfibres, nylon, polyester) for technical applications as well as applications in the fields of safety, fashion, and decoration. A relatively thick (heavy) layer of soft/elastic hardening primer is used with these product forms in order, on the one hand, to retain the flexible character of the textile and, on the other, to guarantee a smooth surface to accept the holographic fine structure.

As it is preferred that a radiation source be located inside the printing cylinder, it is necessary that the printing cylinder and, if necessary, its carrier be radiation-transparent.

The shaping matrix can be manufactured (shaped) as a cylinder sleeve or endless loop and be glued or welded ultrasonically.

In a preferred process, the transparent, UV-permeable shaping matrixes are fixed on the radiation-permeable printing cylinder by means of optically clear liquid adhesives or by means of optically clear transfer adhesives.

Based on experience, matrixes should be manufactured as sheeting or wrap-around plates with thicknesses of 50 my to 250 my.

In accordance with another preferred process, the cylinder sleeve or loop itself is first cast on the interior of a structure-bearing negative shaping cylinder.

This shaping can be carried out by means of infrared-hardening, chemical hardening (two components), or preferably by means of UV-hardening media. Hardening occurs as a result of radiation from the interior of the negative cylinder.

In order to guarantee a uniform wall thickness and the smoothness of the inner surface of the inventive matrix to be produced, the form-accepting medium, which forms the matrix as a sleeve or loop after the shaping, can be transferred in the spin process, i.e. by means of rotation of the negative shaping cylinder.

The layer thickness of the shaping medium (the subsequent matrix) is between 50 and 250 my or more corresponding to the requirements of further processing.

The special feature of the matrix or of the shaping medium is its transparency for UV-radiation.

The shaping structure is shaped in advance in sheeting or thin plates by the surface relief hologram, which can be fixed to the interior of the negative shaping cylinder.

The negative shaping cylinder can consist of at least two or more cylinder side pieces (partial cylinders) which can be opened (swung open) for shaping after the hardening of the positive sleeve forming the matrix.

However the positive sleeve can also be removed from the interior surface of the vacuum cylinder by means of a vacuum suction device.

In order to facilitate shaping and to prevent the fine structures cramping, 0.2 to 2% by weight of the separating agent, e.g. hydroxylated polysiloxane, Type Q4-3667 from Dow Corning, USA, or Pura-Additiv 6845 or 6890 from Pura International, Germany, can be added to the shaping medium.

The cylinder sleeve (matrix) manufactured in this way is then shrunk on the printing cylinder or the printing cylinder is shrunk temporarily, for example by cooling it in nitrogen, prior to the sleeve being slid on. After the normal temperature has been reached again and, therefore, the cylinder has expanded again, the sleeve has a firm seat. On the other hand, the printing cylinder also expands during the printing process as a result of the partial absorption of UV-radiation and its conversion to heat to such an extent that the sleeve is firmly seated. And finally, the latter can also be glued.

The cylinder sleeve (matrix) can also be manufactured in a larger circumference, so that it forms an endless loop. This is guided around the printing cylinder and an additional roller by means of which the tension of the endless loop can be regulated.

An essential criteria in establishing the exterior circumference of the printing cylinder/sleeve system or of the loop/printing cylinder/tension roller system should be to choose a measurement corresponding to one time or several times the printing format length or cylinder circumference of the different rotative processing machines in the graphics industry. For example, these can be rotation printing machines or rotation stamping machines, laminating machines, or combinations of the above machines.

The normal printing format lengths or roller windings are usually one time or several times the 12-inch system or the 24-inch system.

However the cylinder sleeve (matrix) can also be shaped directly on the positive cylinder, as described below: in this preferred process the smooth printing cylinder is first placed concentrically in the original negative shaping cylinder.

The wall spacing between the inner wall of the negative shaping cylinder and the surface of the printing cylinder corresponds to the wall thickness of the cylinder sleeve produced.

In order to guarantee a constant wall thickness of the shaping medium, the negative shaping cylinder and the positive cylinder are positioned concentrically on a common axis.

The sum of double the sleeve wall thickness plus the net diameter of the printing cylinder corresponds to the gross diameter of the positive shaping cylinder which, multiplied by  $\pi$ , gives the desired repeat length (winding) or picture format length.

The matrix is preferably UV-hardened by radiation from the interior of the UV-permeable positive cylinder. Producing the cylinder sleeve (matrix) in accordance with this process results in the essential advantage that the sleeve is installed directly and without any seam at all on the printing cylinder and can stay there.

After printing, however, sleeves manufactured according to the invention can be removed very easily again and the cylinder can be fitted once again with another sleeve because they are made essentially of plastic of a low thickness.

The matrixes described above, which are attached to the cylinder as winding plates, can be removed just as easily, after which other matrixes can be placed on the printing cylinder once again.

In order to attain tighter control of the printing material on the cylinder while the web of the printing material is encircling the latter and, therefore during the shaping process, an additional flexible loop can be used in the roller system if necessary.

The tension of this loop can be regulated by means of spindles, for example, via a tension roller placed in sliding blocks.

The radiation angle of the UV-radiation source located in the shaping cylinder can be varied by means of overlapping round and concentrically placed screens. The axial length of the UV-radiation can be focussed more or less strongly in the same way by means of an adjustable concave mirror also located in the shaping cylinder.

The invention is explained below in more detail with reference to embodiments. The figures show as follows:

- Fig. 1 a sectional view through the layer structure of a heat-seal hologram based on the state of the art,
- Fig. 2 a sectional view of the layer structure of a printing material structured in accordance with the invention,
- Fig. 3 an enlarged representation of a surface layer section,
- Fig. 4 a diagrammatic view of a printing device,
- Fig. 5 an alternative printing device with a shape-bearing endless loop,

- Fig. 6 a printing system with several printing units connected one behind the other, and
- Fig. 7 process diagrams for the manufacture of a printing cylinder.

Fig. 1 shows the structure of stamping sheeting in the so-called "heat-seal technology" in accordance with the state of the art. Such sheeting is manufactured by a thin wax- or silicone-containing separating layer (2) being applied to a polyester belt (1) approximately 12 to 25 my thick and then a lacquer layer (3) of 0.9 to 2.5 my (or 1.1 - 3.25 g/qm) being applied, and then again a 0.05 to 0.2 my thick metallic reflection layer (4), such as aluminium. Three hundred angstroms provides a good optical density of 1.8 - 2.

The hologram is stamped into the lacquer layer (3) by means of the metallization (4) as a so-called stamping hologram, which normally is present as a relief structure in a stamping matrix made of nickel.

A temperature-activateable adhesive (5) (hot-melt glue), 0.7 g/qm, by means of which the data-bearing lacquer layer is transferred to and fixed onto the printing material, is then applied.

In order to apply the "heat-seal hologram," the sheeting manufactured in this way is brought into close contact with a printing material, e.g. paper or cardboard, under the application of heat, e.g. 110°C to 130°C and pressure, e.g. 50 - 150 kp/cm and more, in which case the hot-melt

glue (5) melts and the separating layer (2) is activated, resulting in a permanent bonding of the lacquer/metallization layer (3/4) with the base.

The polyester sheeting (1) is then separated at the separating layer (2), so that only the lacquer layer (3), the metallization (4), and the hot-melt glue (5) are left on the printing material.

It is to be pointed out that in this process variation the stamping of the hologram occurs from the side of the metallization (4) and, therefore, the stamping plate can be manufactured true to side so that the hologram can be viewed from left to right when subsequently viewed through the clear lacquer layer (3).

Fig. 2 shows the structure of a hologram on a carrier (6) which was applied in accordance with the process in DE A 37 44 650. The carrier (6) is paper or cardboard. However it can also be clear or opaque plastic or a different carrier.

In order to achieve a complete stamping and, therefore, a good modulation and diffraction efficiency of the hologram to be applied, a high surface smoothness of the carrier is desired.

If this is not the case, during the stamping or shaping "orange peel-like" distributions of stamped and unstamped areas results as well as a dull, blurred, and

diffusely reflecting surface and an inadequate overall brightness.

Up to now irregularities in the density and in the thickness of the printing material were compensated to a certain degree by means of flexible counter-pressure rollers. In that case the counter-pressure rollers or forms could exhibit silicone rubber or similar coatings for example. Based on experience, these should have a Shore hardness of 60 to 90.

So-called "art papers and cardboards" which can be obtained on the market may also be suitable, for example as carriers, for purposes of the invention, because they have a pre-compressed "core" underneath the finish of the surface and have a good surface quality on account of a machine-applied or cast-applied coating.

As a base for the shaping lacquer (7) to be applied subsequently and the smooth primer which may be applied, the printing material (6) should preferably have a machine-applied or cast-applied surface (10) in order to close the pores and to optimize the surface quality in so far as smoothness and roughness is concerned.

Pre-smoothing of the surface, which may be necessary, is carried out during the hardening of the primer by shaping by a polished cylinder or a smooth endless loop or by a smooth cover sheet which is removed again after hardening.

The radiation-hardening shaping lacquer (7) is preferably applied in a thickness of 1.5 to 2  $\mu$ m to the smooth or pre-hardened surface of the carrier (6) or of the finish (10). The finish (10), which may be applied to the carrier (6), and the primer, which is applied if necessary, effectively prevent the lacquer being absorbed into the carrier (6) and produce an optimally level surface of the carrier.

On account of the extreme fineness of the structures to be stamped with a stamping depth of between 200 nm to 1,000 nm and a resolution between 800 to 1,800 lines per millimetre, it is absolutely necessary to even out any remaining surface irregularities with the thickness of the radiation-hardening shaping lacquer layer. Depending on the surface structure of the printing material or on the use of the primer, the thickness of the stamping lacquer layer can be from 2  $\mu$ m to 10  $\mu$ m or also up to 20  $\mu$ m. Based on experience, lacquer layers of 1.5 to 15  $\mu$ m in thickness are applied, depending on the condition of the surface.

A mirror-like even surface of a primer layer is preferably attained on a polished cylinder during hardening or drying.

The inventive shaping method is based on the shaping and hardening of the lacquer and of the fine structures in contact with the matrix, loop, cylinder sleeve, or roller, radiation-hardening lacquers being used preferably.

The hardening or cross-linking can be triggered and carried out by ultraviolet or electron radiation hardening.

Finally, a 20 to 200 nm thick metallization (8), e.g. aluminium, is applied to the shape-bearing lacquer layer. This metallization produces the reflection of the viewing light of the hologram and exhibits a good optical density or reflection at a thickness of 300 angstroms for example.

The metallization is preferably applied after the hologram structures have been shaped.

Where a smooth primer is used or where the surface of the printing material is already mirror-smooth, e.g. with plastic sheeting, the metallization can also be applied directly to the primer.

With opaque, i.e. non-transparent printing materials, the stamping is carried out in such a way that the stamping die has to be prepared on a laterally inverted basis.

For subsequent protection of the hologram surface, a protective lacquer (9) or another transparent, possibly coloured, protective layer, can then be applied to the metallization layer (8).

The inventive process results in a hologram carrier which is manufactured in direct process stages.

In contrast to the state of the art, in which the stamping has to be done into a carrier which must then be transferred, direct shaping into the printing material can be carried out as a result of the inventive process. This results in a very high cost reduction and a considerable acceleration of the printing process.

In the preferred embodiment of the invention, the lacquer (7) consists of one or two different layers, in which case the first lacquer layer applied to the printing material or to the cast layer (10) is supposed to provide a mirror-smooth surface. The sole lacquer layer or the second carries the information.

Preferably, the metallization (8) is vapour deposited onto the lacquer layer, however it can also be applied in another manner, e.g. by an indirect transfer metallization, provided the hologram structure is transferred after the metallization.

In addition to the goal of producing light reflection, the above metallization (8) has the advantage of allowing for an immediate visual quality control of the stamping result by eye or measurement of the diffraction efficiency or reflection.

In a completed system, 5,000 to 25,000 pieces per hour and more could be attained with the inventive process.

Fig. 3 shows an enlarged sectional view between the real, the hologram-bearing layers. The shaded area corresponds to the shaping depth of the relief structure of the hologram. It can be seen that the deepest point of the shaping ends within the lacquer layer (7). Therefore the lacquer layer (7) is to be chosen in a thickness such that the shaped relief structure does not penetrate into the carrier.

Furthermore, the lacquer layer (7) is to be chosen with a thickness such that it is still possible to even out any remaining irregularities in the carrier (6) or the surface coating (10).

In addition to holograms, other light-diffracting structures and so-called diffraction grids, which were cut and engraved mechanically or by laser engraving for example, can be stamped.

Where the surface quality is sufficiently high, which is determined essentially by the layer structure of the printing material, the process described here makes possible direct mass reproduction at much lower costs than incurred with the previously described three-stage process of shaping, adhesive coating, and application to the printing material or than with the direct but hardware-intensive electron radiation process.

Fig. 4 shows a diagram of a device for replication and simultaneous application of a hologram to a printing material.

A printing material exhibiting a uniform surface quality and which is drawn over a set of rollers (16, 17) is on a roller (11). The printing material is guided over the printing cylinder (14) via a further set of rollers (22, 23), encircling the cylinder approximately 180° or less. The printing material is then fed through a set of rollers (30, 31), a further set of rollers (24, 25), and between two rollers (18, 19) a winding roller (13).

If a carrier material is used, it can be fed as web (37) through the application device together with the printing material and wrapped onto the roller (12) via the set of rollers (26, 27) and between two rollers (21, 22).

In order to increase the contact pressure of the printing material to the printing cylinder, a belt loop (15) can be guided over the surface of the printing cylinder (14) together with the printing material. The loop encircles the rollers (23, 30, 29, and 28) and, if necessary, can also be guided under the tension roller (36), which regulates the web tension.

Via a spreading unit (34) with a spreading roller (35) a lacquer layer is applied to the printing cylinder or, alternatively, at a roller (23) onto the web which then runs in between the roller (23) and the printing cylinder and printing material encircling the printing cylinder.

The printing cylinder (14) is produced as a quartz or acrylic glass cylinder (PMMA) and has a radiation source

(33) in its interior, in particular a UV-light source. In order to direct the emission of light, a parabolic concave mirror (39) and screens (38) are provided which can be adjusted and regulate the area on the printing material guided over the printing cylinder affected by the UV-light.

In focussing the radiation on a more or less wide strip or slit, the arc of wrap of the printing material around the printing cylinder can be reduced correspondingly.

The interior of the printing cylinder has a ventilation device which feeds in cold air, on the one hand, and, on the other, suctions off ozone.

In order to attain a high degree of efficiency, a water-cooled pipe burner can be used.

As the lacquer applied via the spreading roller (35) can be hardened by radiation, it already hardens during the circulation of the printing material over the printing cylinder to such an extent that it can be easily guided over further rollers and can be wound onto the take-up roller (13) or (12) respectively without the surface structure being affected.

An electron radiation source with a suitable lacquer system can also be used in place of a UV-light source. Common to the processes, however, is the fact that a relatively liquid lacquer system is applied to the printing

material which can already be hardened without substantial pressure during the shaping on the matrix. Where a UV-light source is used, this is achieved in particular by the fact that the inventive printing cylinder and the inventive matrix itself are designed to be UV-light transparent, so that hardening can be carried out from the interior of the printing cylinder.

Fig. 5 shows an alternative device in accordance with Fig. 4 in which a shape-bearing endless loop is used in place of a printing cylinder.

The endless loop (40) can take up several micro-structures or printing format lengths one after the other. It is fed over the pressure cylinder (14) and a reversing roller (41). This device allows matrixes to be changed quickly in the printing unit. In addition, with this variation different printing format lengths can be easily accommodated without changing the printing cylinder.

The spreading roller (35) applies the lacquer directly to the endless loop (40). Otherwise, the device in Fig. 5 corresponds to the device in Fig. 4.

Fig. 6 shows a device consisting of several printing units. The individual printing units correspond essentially to the devices in Fig. 4 or 5. In a first printing unit a primer is applied to the printing material in order to smooth it sufficiently on its surface. The primer applied can also be hardened by UV-radiation.

The actual application of the micro-structure to the printing material is carried out on the main printing unit (46). If desired, a second printing unit (47) can be connected, arranged in a reverse orientation to the main printing unit and allowing for the back of the printing material to be printed on.

In order to hold the web tension of the printing material constant and to make it possible to correct the longitudinal registers of the web, compensating rollers (42, 45) are provided. A spreading unit (34, 48 or 49 respectively) is allocated to each printing unit.

Fig. 7 shows a diagram of the process to manufacture a printing cylinder.

Right at the bottom is the glass substrate (54) with the exposed and developed photoresist layer (53), which contains the surface structure hologram. The UV-hardening shaping medium is applied to the holographically structured photoresist layer (53).

This is done by spray casting (nozzle application device, a number of proportioning nozzles with defined diameters moves linearly over the plate), by immersion, by spiral application, or casting and spinning.

The layer thickness should be at least 2  $\mu$ m and more.

A UV-transparent acrylic sheeting or acrylic plate (PMMA) is positioned (51) on the shaping medium in close contact to it as subsequent carrier of the shaping medium.

This plate or sheeting must be flexible in order to make easier detachment possible following hardening and to facilitate the further assembly and reproduction steps.

A quartz glass plate (50), which is also UV-transparent, is positioned on the acrylic sheeting in order to guarantee absolute flatness and close contact of the acrylic sheeting (54) to the shaping medium (52) by means of uniform pressure.

Preferably, this shaping or printing process is carried out in a vacuum printing frame in order to guarantee optimal contact of the printing layer and to prevent air bubbles.

Following the printing process by means of UV-exposure, the acrylic sheeting is detached from the photoresist and either printed again for purposes of multiple use copies (ganging up) or adapted to the negative shaping cylinder.

This sandwich of acrylic and shaping medium is now inserted into the interior of a negative receptacle (55) which preferably consists of four shaping jaws linked to one another via joints (56 - 58). After the negative shaping receptacle (55) is closed, the shaping medium is located within the hollow cylinder as "interior coating."

A quartz glass cylinder (54) is now inserted concentrically into the negative shaping receptacle (55). The relevant process stage is illustrated in Fig. 7d.

Fig 7e shows the device to manufacture the printing roller. A shaping lacquer provided in a tank (59) is fed via pipes (60) into the space between the glass cylinder (54) and photoresist (52). The filling of the space and degassing is supported by a connected vacuum (61). The shaping lacquer is hardened by means of UV-light, an appropriate light source being provided within the glass cylinder (54).

After the shaping lacquer is hardened, the negative shaping receptacle can be opened and the printing cylinder (62) removed. The latter then bears on its surface the micro-structure produced via the photoresist (52).

Following insertion of the printing cylinder (62) in a printing unit, the actual printing of the printing material can take place.

**Reference number list**

1	polyester carrier
2	separating layer
3	lacquer
4	metallization
5	hot-melt glue
6	carrier, printing material
7	lacquer
8	metallization
9	protective lacquer
10	cast finish
11	roller
12	roller
13	take-up roller
14	printing cylinder
15	loop
16, 17	set of rollers
18, 19	set of rollers
20, 21	set of rollers
22, 23	set of rollers
24, 25	set of rollers
26, 27	set of rollers
28, 29	set of rollers
30, 31	set of rollers
32	roller
33	radiation source
34	spreading unit
35	spreading roller
36	tension roller
37	web

38	screens
39	concave mirror
40	endless loop
41	roller
42, 45	compensating rollers
46	main printing unit
47	counter-pressure unit
48	application unit
49	application unit
50	quartz glass plate
51	acrylic plate
52	UV-hardening shaping medium
53	photoresist
54	glass substrate
55	glass cylinder
56	negative receptacle
57, 59	joints
60	tank
61	pipes
62	vacuum connection
63	printing cylinder

**Patent Claims**

1. Process for the simultaneous replication and direct application of a micro-structure, in particular of a hologram or another diffraction grid, onto a printing material (6) especially paper or cardboard, in the shaping process using a matrix bearing the micro-structure as surface relief structure with which one or more lacquer layers (3, 7, 9) are applied to a printing material (6), these layers smoothing the surface of the printing material (6), and with which the hologram is shaped into the surface of the coating applied to the printing material (6), in which case the lacquer layer (3) accepting the micro-structure can be hardened by radiation, particularly UV-radiation, characterized by the fact that the lacquer layer (3) is hardened during the circulation of the printing material (6) around a cylindrical shaping cylinder from the matrix side through the radiation-transparent shaping cylinder with a radiation source (33) located in the interior of the shaping cylinder.
2. Process in accordance with Claim 1 characterized by the fact that the UV-transparent shaping matrix is designed as an individual matrix, endless loop, as a cylinder or as a cylinder sleeve.
3. Process in accordance with Claim 1 characterized by the fact that a separating agent of 0.2 to 2% by weight is added to the radiation-hardening shaping material in order to make it possible to detach the

hardened shaping medium and to prevent the holographic positive/negative fine structures cramping.

4. Process in accordance with Claim 3 characterized by the fact that the separating agent is chemically adjusted in such a way that the hardening shaping medium exhibits a much greater adhesion to the printing material than to the matrix.
5. Device for applying a hologram to a printing material (6), especially paper or cardboard, to carry out the process described in Claim 1, the web-like printing material (6) being guided over a matrix bearing the hologram as surface relief structure and a radiation source is allocated (33), in particular a UV-radiation source, is allocated to the matrix, which radiation source can harden a radiation-hardening lacquer layer (3) applied to the printing material (6) during contact with the matrix, characterized by the fact that the radiation source (33) is located in the interior of the cylinder-like printing cylinder (63) and that the lacquer layer (3) can be hardened by the radiation-permeable printing cylinder (63) and the radiation-permeable matrix.
6. Device in accordance with Claim 5 characterized by the fact that the radiation source (33) is an ultraviolet light source or an electron radiation source.
7. Device in accordance with Claim 5 characterized by the fact that the printing cylinder (63) or the matrix

receptacle respectively consists essentially of plastic, in particular UV-transparent acrylic glass (polymethyl methyl acrylate, PMMA).

8. Device in accordance with Claim 5 characterized by the fact that radiation path of the UV-light source is designed so that it can be adjusted by means of optical reflectors, screens (38), and/or focussing devices.
9. Device in accordance with Claim 5 characterized by the fact that the device consists of one, two, or several printing units (46, 47) located one behind the other or which can be retrofitted modularly.
10. Device in accordance with Claim 5 characterized by the fact that two printing units (46, 47) located opposite to one another print the front and back of the web simultaneously and accurately.

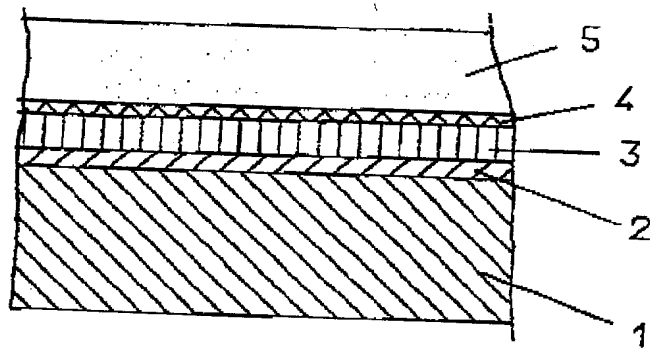


Fig. 1

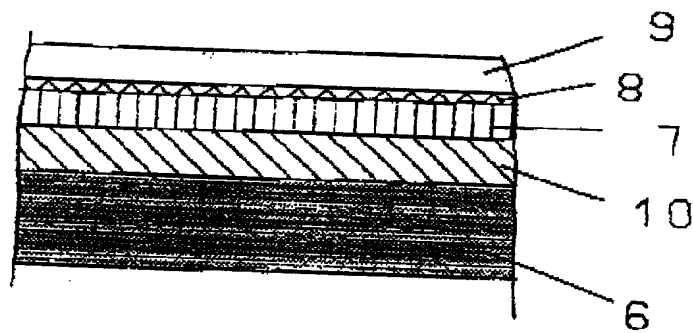


Fig. 2

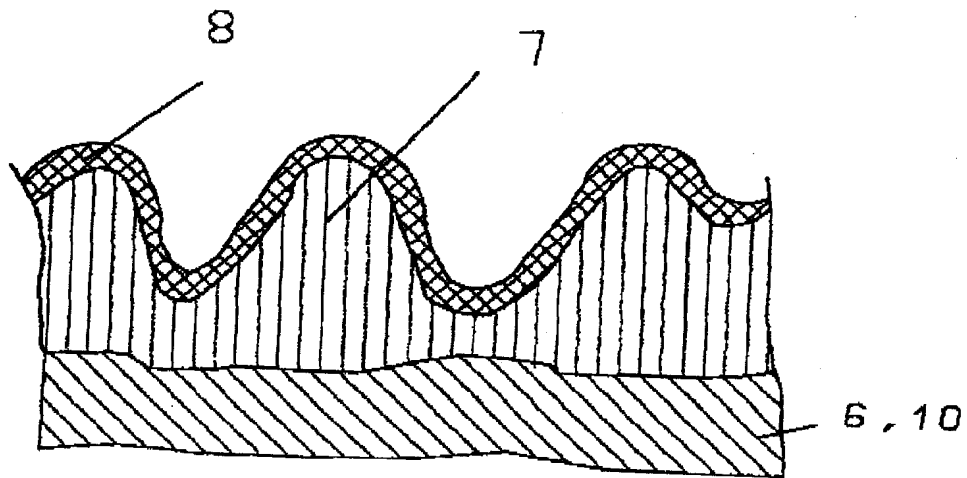


Fig. 3

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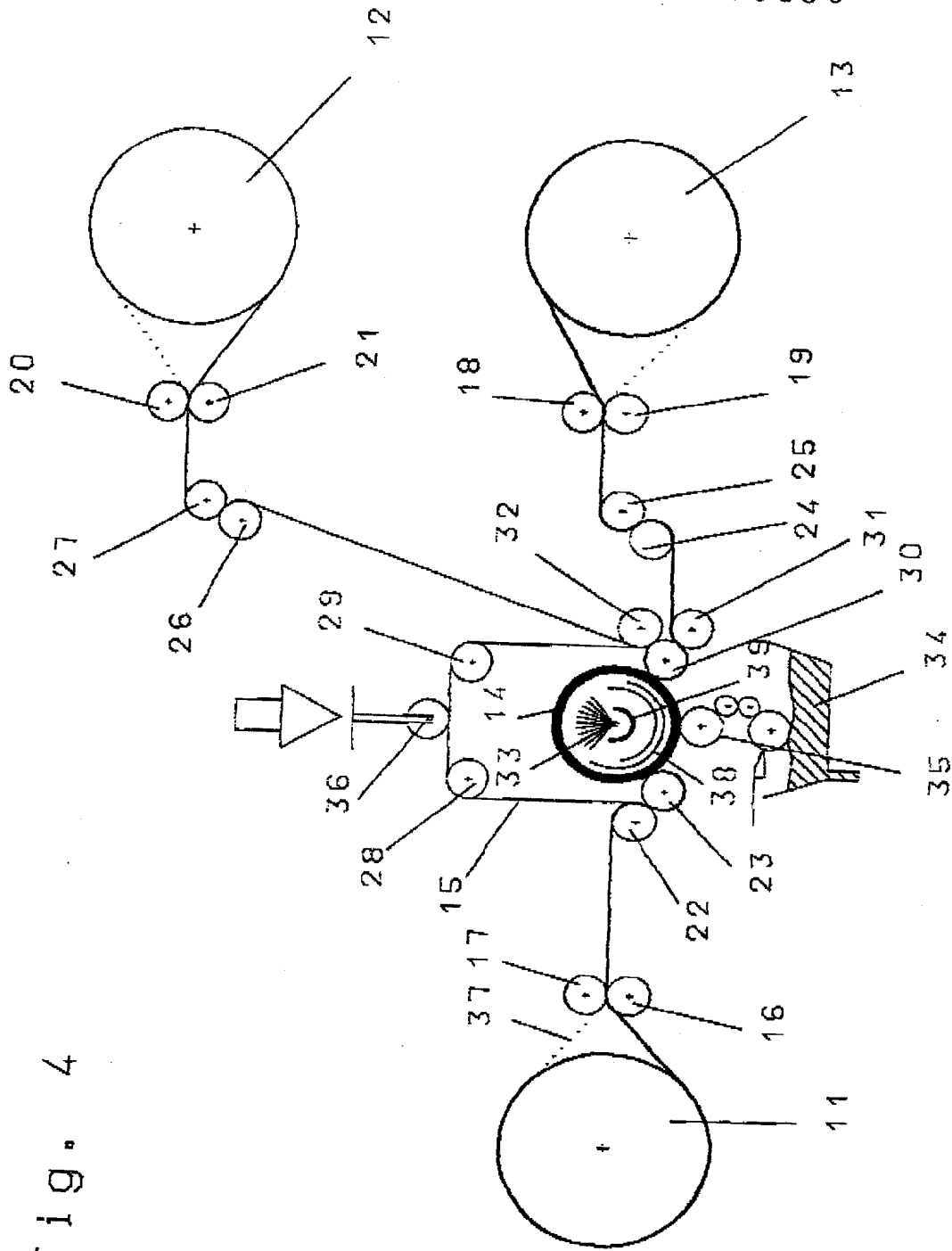


Fig. 4

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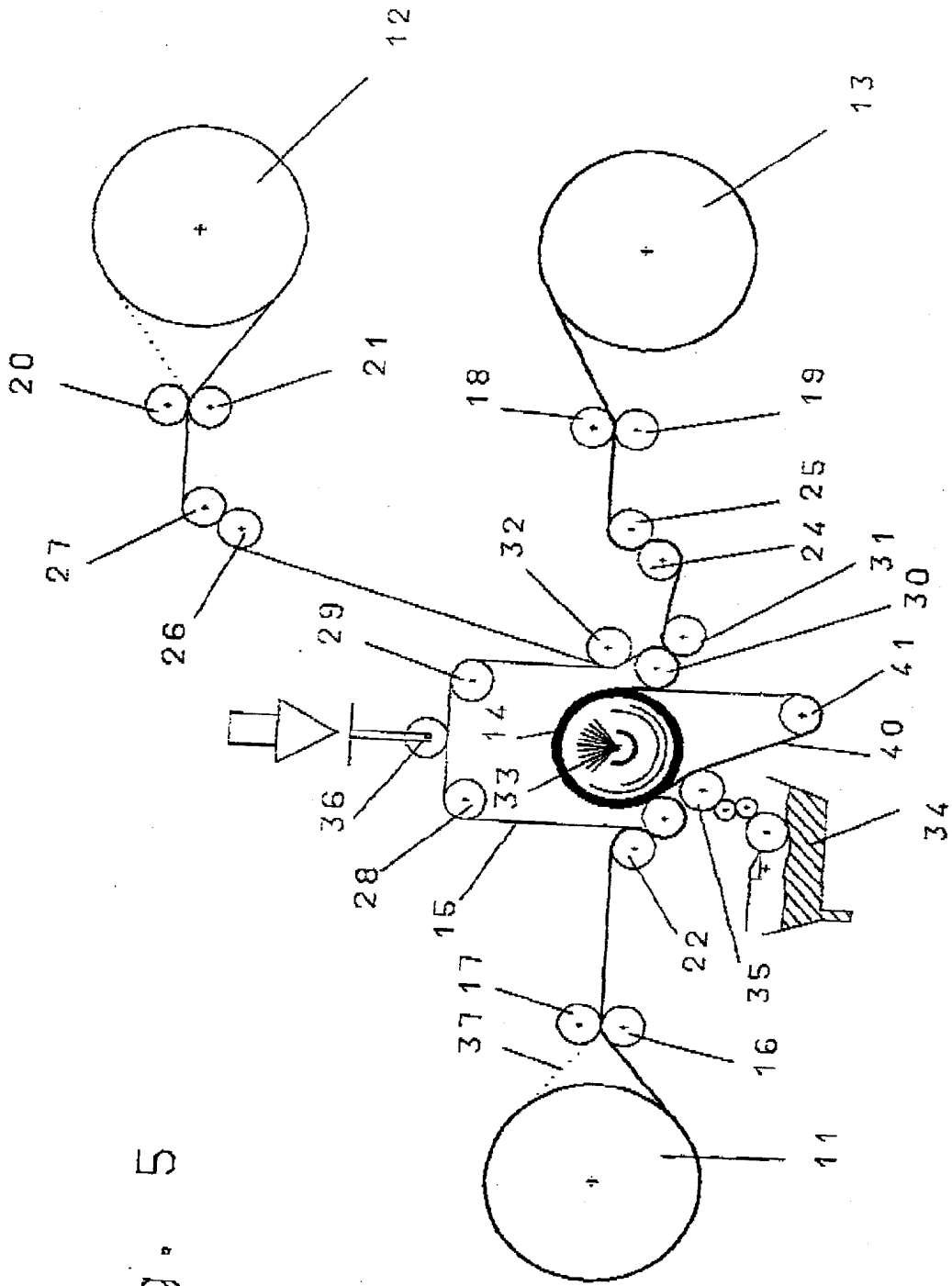
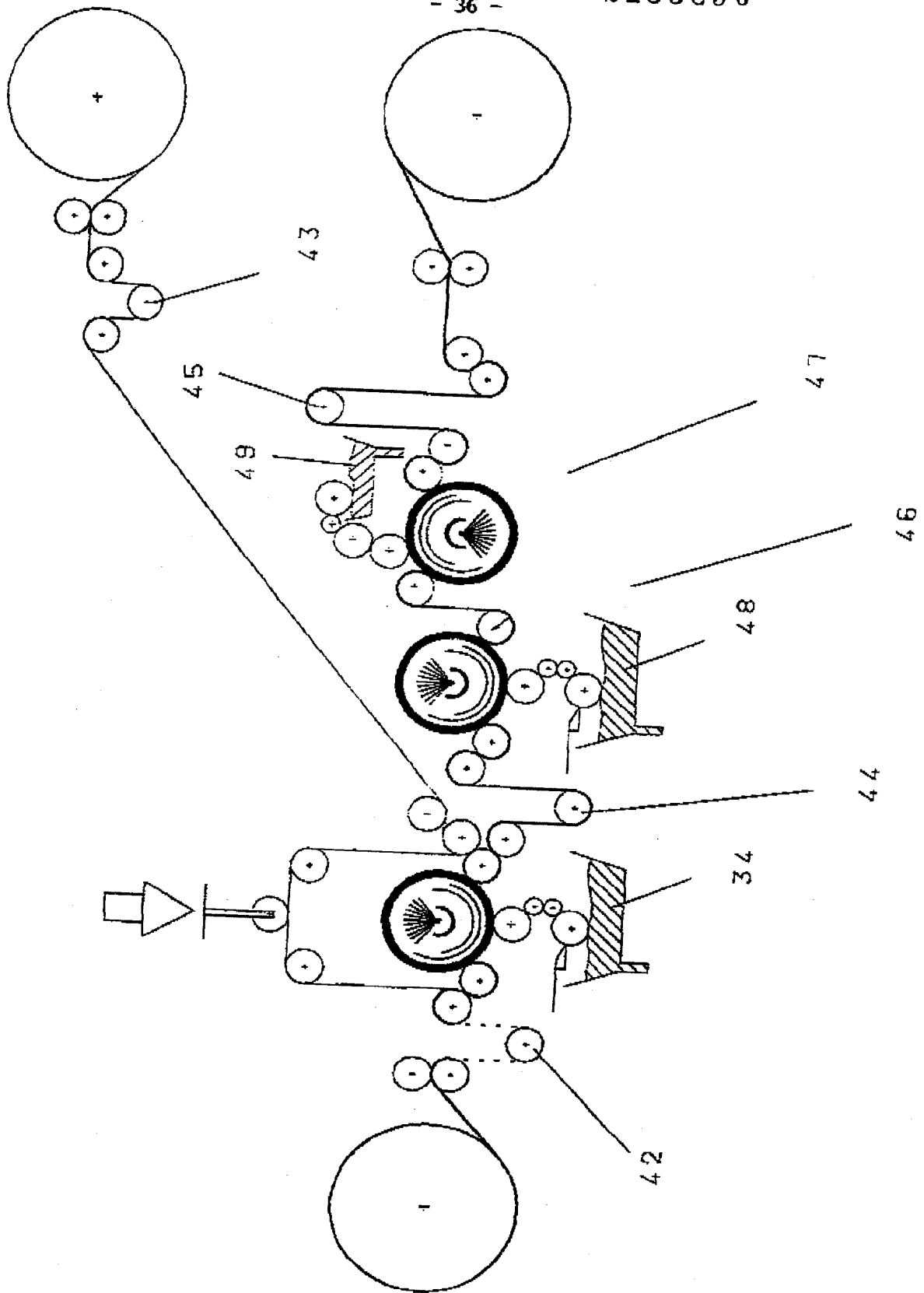


Fig. 5

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Fig. 6



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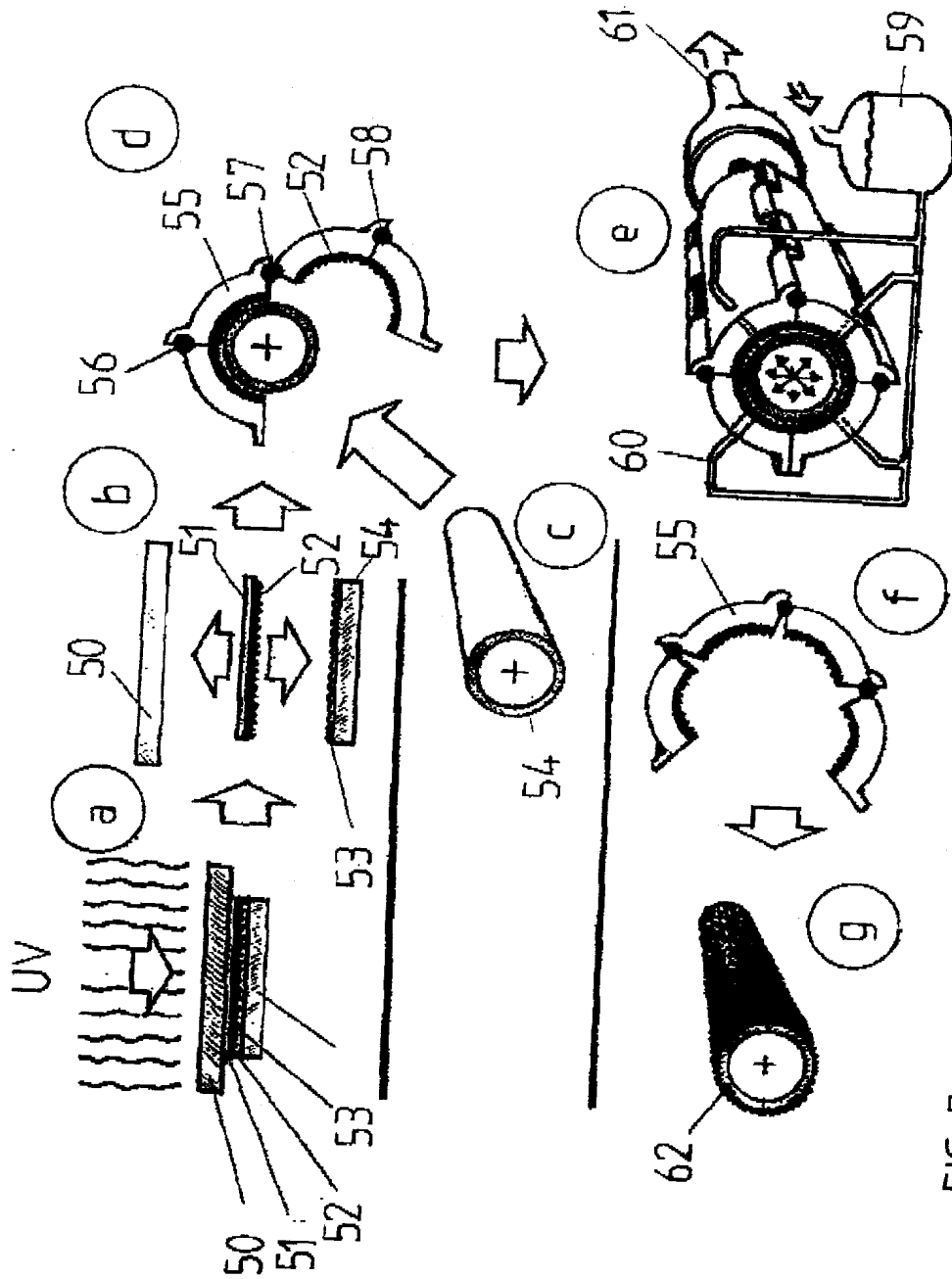


FIG. 7